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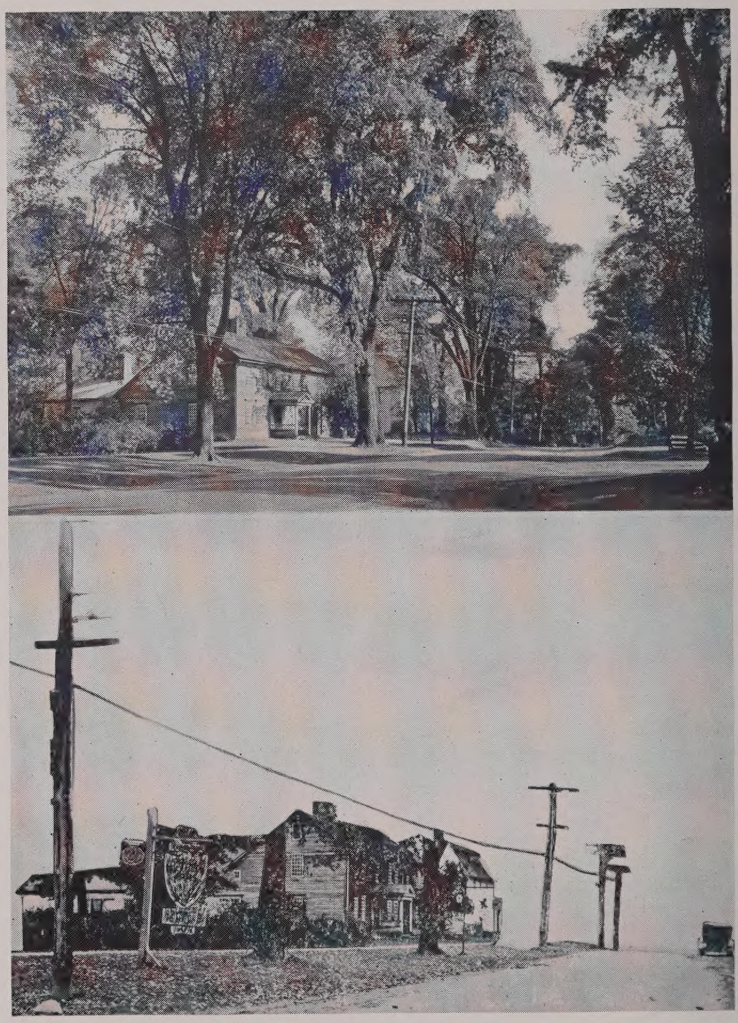
The Dutch Elm Disease

A New Threat to the Elm

By Malcolm A. McKenzie and William B. Becker

Although the Dutch elm disease has not been found in Massachusetts up to this time, nevertheless it constitutes a serious threat to the future of the State's principal shade tree. This bulletin is intended to supply basic information concerning the characteristics and spread of the disease.

MASSACHUSETTS STATE COLLEGE
AMHERST, MASS.



UPPER: Present-day Scene Along an Elm-shaded Street in a Massachusetts Town.
LOWER: As the Same Street Would Appear if the Elms were Destroyed.

MASSACHUSETTS AND HER ELMS

Massachusetts cherishes her elms far beyond any monetary estimate which might be placed upon them, but some idea of the investment in dollars may help all of her citizens to appreciate more fully the true worth of her principal shade tree. In a recent elm census report, the value estimated for the elms in four Massachusetts cities and towns was conservatively placed at $7,300,000.

Far in excess of money value, in a hundred ways to which we seldom give a single thought, the elms of Massachusetts really contribute generously to the life, well-being, and happiness of the people throughout the State. If you have not already had occasion to appreciate the extent to which these trees affect your daily life and community associations, take a trip to some part of the United States where shade trees and particularly where elms do not adorn the streets and lawns of the communities. However, if you will, you can appreciate the value of your elms without traveling beyond the limits of your own city or town. Simply walk along one of your elm-shaded streets in midsummer and try to picture to yourself what effect the elimination of the elms would have upon your community.

Without the elms in Massachusetts one would find barrenness and desolation on the streets and commons instead of the charm that has become the legend of New England *with the elms*. Various ornamental structures for purposes of illumination might be installed as objects of beauty or otherwise to replace lost elms, but these graven substitutes are at best poor seconds for the natural beauty, symmetry, life, and shade of the elms.

The photographs on the opposite page show a present-day scene in a Massachusetts village street and the effect produced by altering a photographic negative to show the same view projected into a future day if our elms should be lost. Only by sustained vigilance can we hope to check any inroads that may be made against the elms by their new enemy — the Dutch elm disease — which is causing serious trouble within fifty miles of our State boundaries to the south and west.

THE DUTCH ELM DISEASE

A NEW THREAT TO THE ELMS

By Malcolm A. McKenzie, Assistant Research Professor of Botany and William B. Becker, Research Assistant in Entomology[1]

Since 1930, when the Dutch elm disease was first discovered in the United States, all persons interested in our principal shade tree have become increasingly alarmed as the number of elms known to be affected with this disease has steadily mounted. From 1930 to 1932 the known cases of the disease in America were limited to less than a dozen trees in Ohio. During the last three years, however, nearly 22,000 cases of the Dutch elm disease have been found in New Jersey, New York, Connecticut, Indiana and Maryland. Up to this time (May 1937) the disease has not been found in Massachusetts.

This publication aims to present to the people of Massachusetts the essential facts concerning the dread Dutch elm disease and to urge every one in the State to cooperate in the effort to protect and preserve our elms.

THE DISEASE

Distribution

As the name implies, the Dutch elm disease was first observed in the Netherlands; and, since the discovery by the Dutch in 1919, thousands of elms in European countries have been killed by the disease. Reports from Europe indicate that the disease exists throughout the extensive range of climatic and soil conditions included in the following countries: Netherlands, France, Italy, Austria, Belgium, Switzerland, Germany, Poland, Czechoslovakia, Balkan States, and Great Britain. The disease is widely distributed in England but has not as yet been found in Scotland.

In the United States, the most serious infestation of the disease at present is found on the eastern seaboard in New Jersey, New York, and Connecticut.

In both Europe and North America, the only continents where the disease has been observed, elms and trees of the closely related genus Zelkova are apparently the only hosts upon which the disease occurs in nature. A few species of elms are reported to be resistant to the disease, but none is known to be immune and the American elm (*Ulmus americana* L.) is very susceptible.

Investigation into the source of the disease in America led to the discovery, a few weeks after the finding of the disease in New Jersey, that burl-elm logs from Europe which were intercepted at the ports of New York, Baltimore, Norfolk, and New Orleans were carriers of the causal fungus. European elm bark beetles from which the fungus was isolated were also found to be present in the logs. It appears probable that at least fifty-eight shipments of elm logs which in some cases are now known to have been diseased and beetle-infested

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[1]The writers are indebted to Profs. A. Vincent Osmun and Arthur I. Bourne, respectively in charge of botanical and entomological investigations, for valuable assistance, suggestions and criticisms during the preparation of the manuscript of this bulletin. Acknowledgment is also made to Miss Gladys I. Miner, Herbarium Curator, for the preparation of the photographic negative used in the lower half of the frontispiece; and to the Division of Forest Pathology, United States Department of Agriculture, and the New York State College of Agriculture, Cornell University, for the use of photographs wherever credited to these sources.

entered four ports of the United States from Europe during the period 1925 to 1934. These logs were delivered by rail to points in the Central and Midwestern States for manufacture into veneer products. Seven small centers of disease infestation have been reported as traceable to imported logs, in addition to the severe infestation in the New Jersey–New York area. Furthur importation of elm material is outlawed by present federal quarantine regulations.

Symptoms

The disease may occur in an acute form evidenced by conspicuous, immediate, and severe wilting (Figure 1). Other cases in which wilting lacks the suddenness characteristic of an acute attack, have been described as chronic. In acute attacks, at first the young leaves and, within a short time, the leaves of the entire tree wilt and wither. If the wilting is particularly sudden, the leaves dry and curl before they turn completely brown or even while they are green. A short time after the wilting starts, the dried and curled leaves begin to fall and within a few weeks most of the leaves will have fallen. If the twigs wilt while they are still green, the retention of the end leaves and crooking of the twig tips are typical early symptoms (Figure 1, insert). The bark on the affected trees from which the leaves have fallen shows no immediate characteristic disease symptoms which would distinguish it from the bark of healthy trees. Within a short time after the leaves have fallen from diseased trees, however, scolytid beetles may infest the bark. The larvae of these beetles are frequently found in considerable abundance under the bark of trees recently defoliated. It is important to note that these beetles, when present under the bark, should not be considered as primary invaders inasmuch as the trees so infested have previously been weakened and usually seriously defoliated. An examination of the wood of such an infested tree should show additional disease characteristics if the tree has been affected by the Dutch elm disease. Frequent reports of observations of this kind have been made during the periods from June until late August.

The chronic type of the disease differs from the acute type mainly in the length of time required for the pronounced symptoms to appear on the affected trees. In some cases the entire summer may be required for the complete defoliation of a tree by this gradual process. During the relatively slow progress of the disease in such cases, individual branches bearing yellowed or wilted leaves, commonly called "flags," may frequently be observed in the tops or in other parts of the trees. Early dropping of the leaves which first showed discoloration is a rather common occurrence. It must be borne in mind, however, that not all early yellowing and wilting of elm leaves is caused by the Dutch elm disease since other diseases, certain insects, and some other types of injuries may cause defoliation.

In some cases "flags" may not appear in any part of an affected tree, but rather a gradual discoloration of the leaves over the entire tree may occur during the summer. The general appearance in such cases is like that of premature autumn coloration. Early defoliation of the entire tree or parts of it frequently results.

Still another chronic type of the disease has been observed in which the affected trees leaf out rather late or fail to develop leaves on some branches. The foliage may be sparse, chlorotic in appearance, and drop prematurely during the summer. The stag-head which eventually develops from the

Figure 1. American Elm Affected with the Dutch Elm Disease.

Some leaves had wilted and others had fallen when photographed.

INSERT, LOWER RIGHT: **Tender Young Twigs of American Elm Showing Crooking of Twig Tips.**

Frequently the larger leaves fall early so that only a tuft of smaller ones remains at the tip.

(Reproduced from U. S. Dept. Agr. Circ. 322, pp. 4–5. August 1934. Photographs furnished by Division of Forest Pathology, U.S.D.A.))

reduced annual growth in these instances is not to be distinguished from the stag-head commonly associated with various other troubles affecting elms.

Sometimes affected trees have been found in a group in which the disease had apparently spread from a central point.

The symptoms of the Dutch elm disease to be observed in winter are relatively few and not such as to be of much assistance in recognizing trees which are affected with the disease. Trees infested with bark beetles, trees which are stag-headed, trees which have dead branches, trees which show excessive suckering, and trees which fail to set flower buds or have dead leaf buds may be suspected of being affected with the Dutch elm disease, and the wood of such trees should be examined for further signs of the disease.

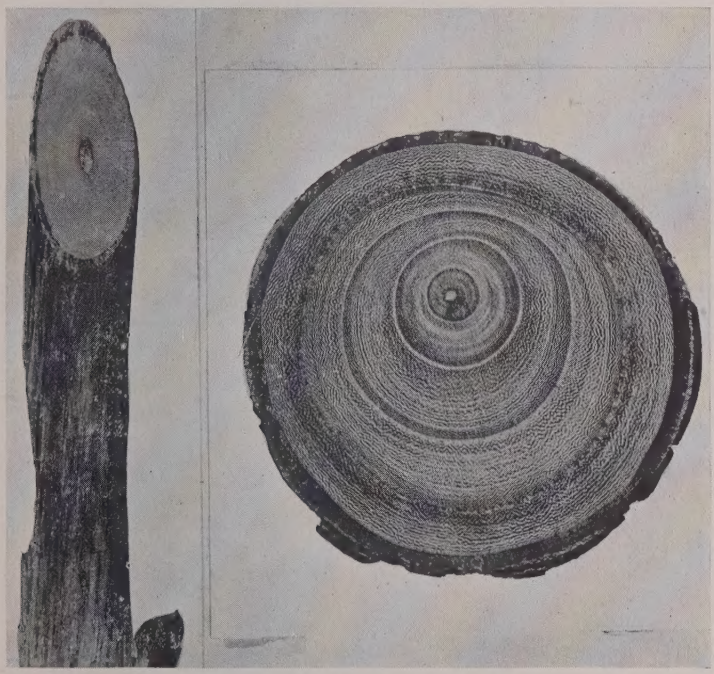

Figure 2. Diagonal and Cross Sections of Young Elm Twig and Branch Affected with the Dutch Elm Disease.

In the latter, the brown discoloration appears in the photograph as a dark concentric ring about ½ inch from the outside circumference of the outer bark. In the former, the discoloration is shown as an incomplete ring 1-16 inch interior to the limits of the cut surface of the twig. x1½.

A diagonal cut made through a twig affected with the disease shows a brown discoloration in the sapwood (Figure 2). Various patterns of discoloration may be associated with the disease. This darkened area may or may not be confined to one annual ring or a part of one annual ring; it may include the entire width of an annual ring or it may be limited to a narrow circle or semicircle in the spring wood, in the summer wood, or in both; and if it appears in more than one annual ring, these rings are not necessarily of

successive years, but normal rings may come between those showing discoloration.

Peeling the bark will reveal the brown discoloration if such has been formed immediately under the bark in the last annual ring. However, peeling the bark of a tree that has formed considerable summer wood may show no discoloration whatever even though it has developed in the spring wood. Usually streaks appear in roots and large branches of trees as well as in the twigs, but discoloration may be somewhat restricted or even confined to a single branch. It appears that discoloration develops to a considerable extent in the sapwood of some trees before any external disease symptoms are noticed.

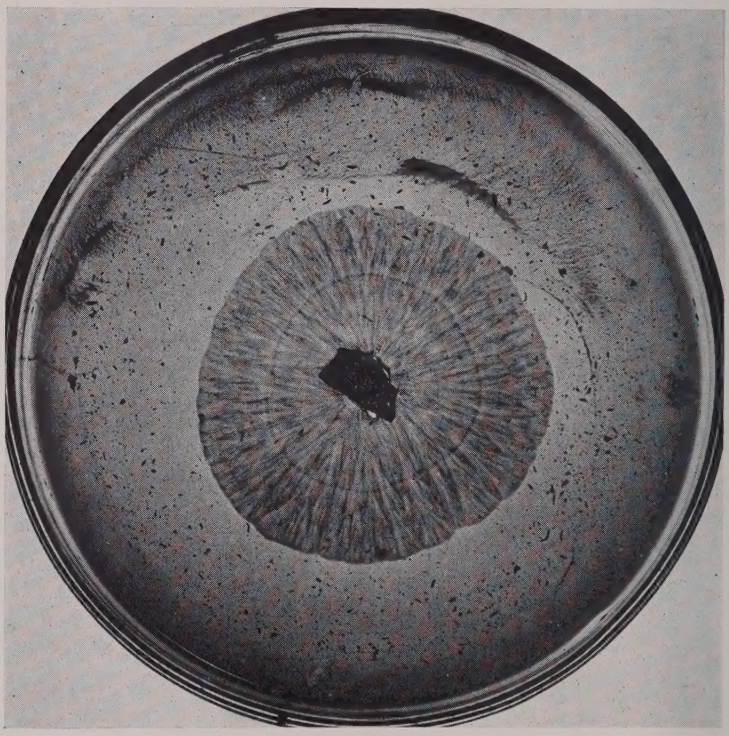

Figure 3. Young Culture of the Fungus which Causes the Dutch Elm Disease. Grown from a tissue planting of discolored wood on potato–dextrose–agar medium. Actual size

A microscopic examination of a thin section of diseased wood shows the discoloration in the wood to be caused by the presence of brown substances in the water-conducting vessels, which are thereby plugged up, or in the immediately surrounding wood. However, a brown discoloration in wood is not limited to wood affected with the Dutch elm disease. Fungus organisms known to be associated with other diseases have been isolated from brown streaks and there may be other causes. Only a laboratory study can determine

definitely whether the fungus which causes the Dutch elm disease is associated with any particular wood discoloration.

Causal Organism

The Dutch elm disease is caused by a fungus which lives in the sapwood. The fungus, first known in only its imperfect stage, was called *Graphium ulmi* Schwarz. Later, on discovery of the perfect or ascigerous stage, the fungus was assigned to the genus Ceratostomella, and the name became *Ceratostomella ulmi* (Schwarz) Buisman. The fungus can be distinguished from other fungi which cause similar wilting in elm by the type of growth and reproductive structures it produces in artificial culture media (Figure 3), and may be isolated in culture from infested trees at any time of year.

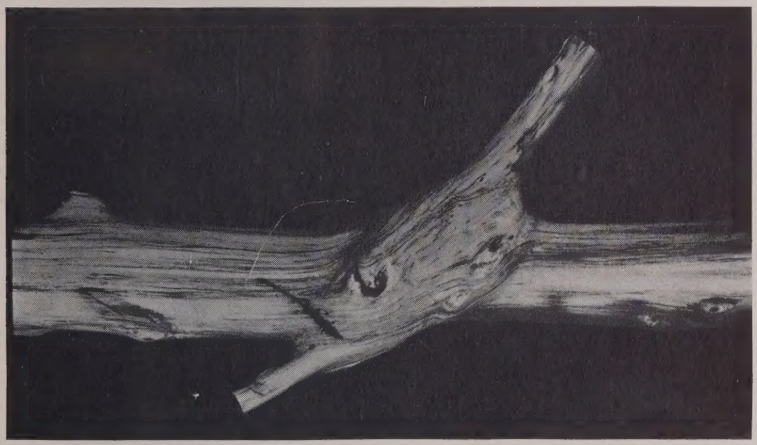

Figure 4. Roots of Two Elm Trees Grafted Together.

Bark removed to show streaks caused by *Ceratostomella ulmi* passing from one root into the other through the graft.
(Reproduced from Phytopath. 25: 1040. November 1935. Photograph furnished by Division of Forest Pathology, U.S.D.A.)

How the Fungus is Spread

The manner in which the fungus is disseminated is not completely understood. Numerous possibilities have been considered, including the following: wind, grafting, pruning tools, birds, and insects. At least one class of transmission agents has been established experimentally.

Wind. From the delicate nature of the spores, or reproductive units, of the causal fungus, it is apparent that these structures are not adapted to withstand the desiccation to which they would be subjected if borne by wind for considerable distances. Moreover, the fact that the fungus in its role as a vascular parasite is, for the most part, not accessible to air currents outside of the host definitely limits the possibility of direct spore dissemination by the wind.

Grafting. Contact of affected trees with healthy trees offers excellent opportunity for the spread of the disease within an area thickly planted to elms. It has long been known that elm branches when in close proximity and subjected to adequate pressure, will become grafted together. Likewise, elm roots in the soil may become grafted together. No better setup for the transmission of a vascular parasite could be devised than the natural condition of grafted roots, which phenomenon is doubtless widespread. In fact, trees affected by the Dutch elm disease have been found with their roots grafted together (Figure 4). Trees planted relatively closely along the banks of streams have been observed to be affected by the disease. Such observations agree with those for trees closely grouped elsewhere.

Pruning Tools. Pruning tools used in tree trimming operations have been considered a possible means of spreading the fungus. Persons engaged in trimming work, where the disease is prevalent, disinfect pruning tools to guard against the spread of the disease. This practice of disinfecting pruning tools is a good procedure in all tree trimming activities since, even when no serious diseases are known to be present, newly introduced or little understood parasites may be active, especially if dead branches are numerous.

Birds. It has been surmised that birds such as woodpeckers and sapsuckers may have a part in the spread of the disease, but there is no proof of this hypothesis.

Insects. From what is known of the distribution of the disease in America, it would appear that there are no agents of dissemination that carry the causal organism for very great distances. American and European elm bark beetles have been proved to be vectors of the fungus and there may be other carrier insects. Believed to be the most important of all carriers are the European elm bark beetles, one species of which is established in the United States. These insects are known to carry the spores of the fungus within and upon their bodies. For the most part, the flight of these beetles is limited to short distances. In some twenty-eight years since their first American discovery in Massachusetts, they have spread somewhat, but not alarmingly, within the State from the originally observed infestation.

Comparative data from recent authoritative experiments tend to indicate that prevailing winds are associated with the relatively long-distance travel of the beetles along the Atlantic coast area of infestation. It might happen, therefore, that beetles which carried the spores of the causal fungus could be wind-borne for some distance; but it is essential to remember that, for the most part, prevailing winds in the area mentioned are seaward and would not generally carry beetles great distances inland. Assuming that the beetles are the principal cause for concern in the spread of the disease, it is somewhat encouraging to observe that their further rapid spread inland along the Atlantic coast is at least partially precluded by natural conditions.

Only time can tell whether additional involved problems are connected with the spread of the disease and it is of utmost importance that laboratory and survey studies on the distribution of the disease and the causal fungus and its carriers be continued in an effort to obtain complete data.

CARRIER BEETLES

Of the elm bark beetles known to be carriers of the Dutch elm disease fungus in Europe, two are considered of prime importance: *Scolytus scolytus* Fab., the larger European elm bark beetle; and *Scolytus multistriatus* Marsh, the smaller European elm bark beetle. *Scolytus scolytus* is considered the more important of the two. In America, however, only *Scolytus multistriatus* is known to be established. It is now considered to be the most important insect carrier concerned in the spread of the causal fungus in the United States.

An elm bark beetle, *Hylurgopinus rufipes* Eich., native to this country, may, because of its habits, prove to be an important carrier. A recent report refers to *Scolytus multistriatus* and *Hylurgopinus rufipes* as the two important vectors of this disease in America.

The Smaller European Elm Bark Beetle (*Scolytus multistriatus*)

This beetle was first found in the United States near Boston in 1909. A survey made in 1933 revealed the presence of the beetle in three rather large distinct areas around the cities of Boston, New York, and Philadelphia. It was undoubtedly introduced into this country at these seaports. Later surveys show that these infestations have enlarged.

In areas where the Dutch elm disease has occurred, there seems to be a definite relationship between the abundance of this carrier beetle and the prevalence of the disease. Because of this apparent relationship, the large infestation of *Scolytus multistriatus* in the Boston area causes some anxiety.

In a survey conducted by this Station in 1935, this beetle was found at two points in western Massachusetts. These new infestations appear to have extended from the New York infestation, which has spread up the Hudson River Valley beyond Albany and also to points in Connecticut not far from the Massachusetts line. Because the Dutch elm disease has spread into the New York area, the western part of Massachusetts should be kept under strict surveillance.

Description of Scolytus multistriatus. The beetle is about one-eighth of an inch long. It is shiny in appearance. The fore part of its body (head and thorax) is black, while the posterior part (elytra) is dark reddish brown in color. The ventral side of the abdomen (venter) slopes abruptly upward toward the rear and has a spine-like projection near the lower edge (Figure 5,A).

How the Beetle Spreads the Disease. The young beetles emerge from tiny shot-hole-like openings in the bark of logs or dying and recently killed elm trees. Some of these may be affected with the Dutch elm disease. Beetles emerging from bark of diseased wood often carry spores of the causal fungus on their bodies and in their digestive tracts. Flying to nearby healthy elms, they may feed upon small twigs, at leaf axils, and sometimes on the buds (Figure 6, upper right). Thus, emerging beetles which carry the spores of the fungus may inoculate trees through bark or bud punctures made in feeding. In this way, healthy elms may become infected. It is possible that wind currents may carry beetles considerable distances beyond their normal flights. In this way, it is not improbable that distant trees occasionally may be attacked by spore laden beetles, and the disease thus introduced

into new localities. After feeding, the beetles fly to the trunks and larger branches of dead or weakened elms or to recently cut elm logs to lay their eggs in tunnels which they dig beneath the bark. These egg tunnels are made by the female beetles and are characteristically parallel to the grain of the wood and bark (Figure 6, upper left). They may be from less than one inch to about four inches in length. Eggs are laid close together along both sides of a tunnel. Tiny larvae or grubs hatch from the eggs and burrow more or less across the grain (Figure 5, C). They shed their skins several times

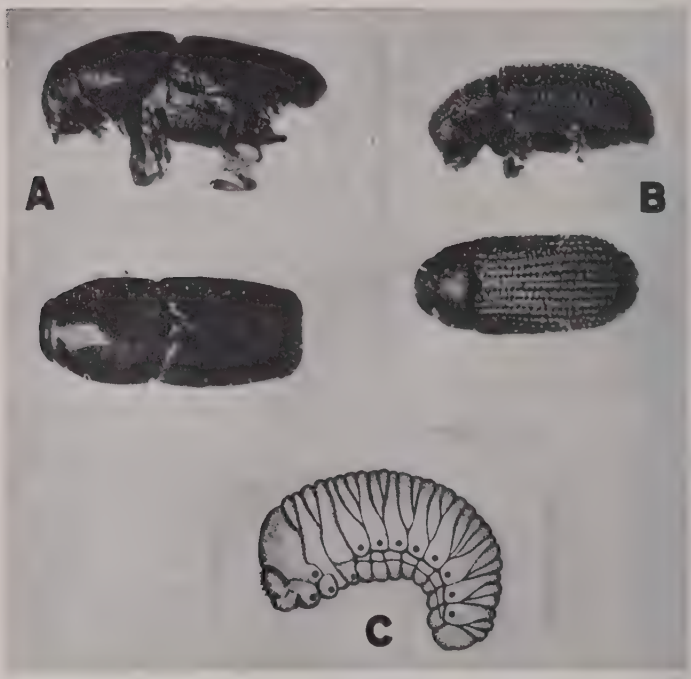

Figure 5. Beetle Carriers of the Dutch Elm Disease.

A. Side and top views of *Scolytus multistriatus* adult. Greatly enlarged.
B. Side and top views of *Hylurgopinus rufipes* adult. Greatly enlarged.
C. *Scolytus multistriatus* larva or grub. Greatly enlarged. (Reproduced from Cornell Ext. Bul. 290.)

NOTE: Grubs of *Hylurgopinus rufipes* are very similar to those of *Scolytus multistriatus*.

as they grow. When full grown, they go through a transformation beneath the bark at the end of these side or larval tunnels, and become adult beetles. The young adults then dig out through the bark leaving the many shot-hole-like openings previously mentioned. When the beetles breed in diseased elms, many more individuals of the next generation will be carriers of the fungus, because the sticky fungus spores form abundantly in the brood galleries of diseased trees.

Several species of tiny mites which are considerably smaller than the beetles also live in these tunnels. Some of these may be carried to new trees on the

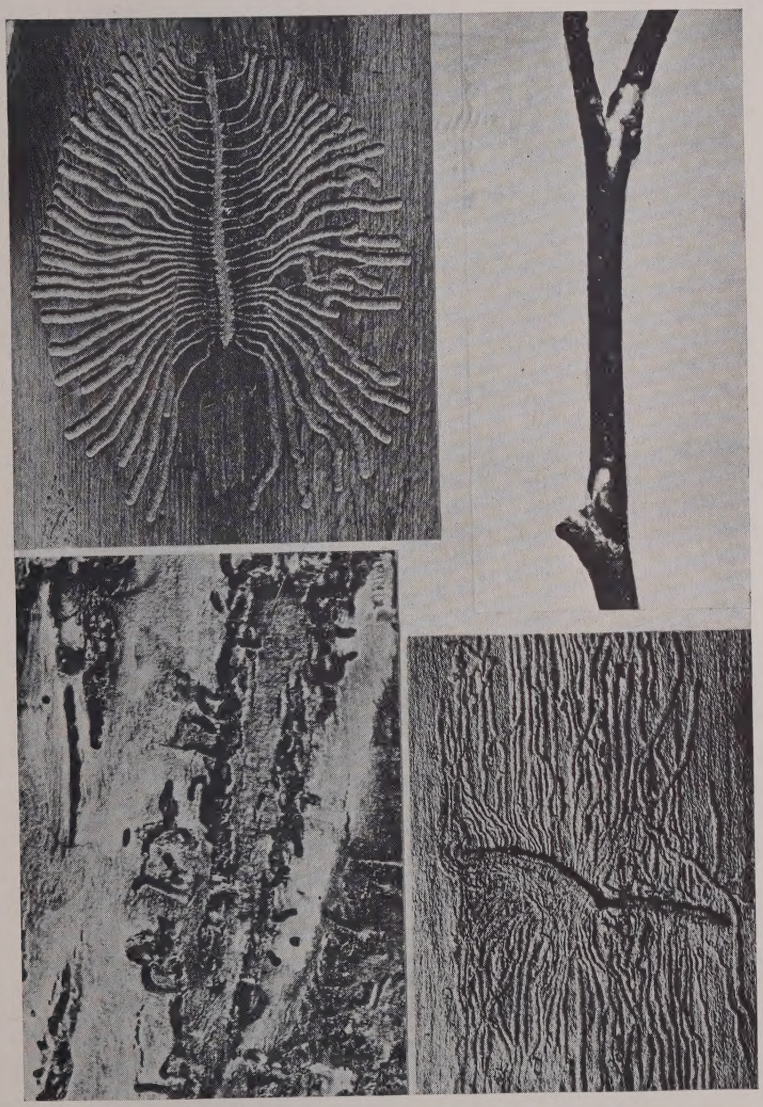

Figure 6. The Work of the Carrier Beetles.

UPPER LEFT: Characteristic egg gallery of *Scolytus multistriatus* beneath the bark of a dead elm tree. Actual size.

UPPER RIGHT: Bark punctures of young *Scolytus multistriatus* adults on twigs of healthy elm tree. x2.

LOWER LEFT: Bark punctures of young *Hylurgopinus rufipes* adults in the trunk of a healthy elm tree. Actual size.

LOWER RIGHT: Characteristic egg gallery of *Hylurgopinus rufipes* beneath the bark of a dead elm tree. Actual size.

bodies of migrating beetles. As these mites crawl about the elm bark, they may be instrumental in local spreading of the fungus over the tree.

Trees weakened by drought, leaf-infesting fungi or insects, or other causes, may become the breeding places of fungus laden beetles, and thus contract the disease. Such trees will, in turn, attract more carrier beetles.

The number of generations produced by the beetle in a season varies with the climate. In warmer regions, there may be two or more generations annually; in cooler regions, only one and perhaps a partial second. The number of generations produced in a given area may be influenced by variation in environmental factors. In that case, there would be an overlapping of generations, and beetles would be emerging throughout the warmer seasons of the year instead of all appearing at approximately the same time.

It is apparent that the life history of this beetle constitutes a vicious cycle, which produces a larger number of diseased trees each succeeding year, if it is not checked.

The Native Elm Bark Beetle
(*Hylurgopinus rufipes*)

It has been shown in experiments that this beetle also can transmit the Dutch elm disease fungus to elm wood and cause trees to become infected. To what extent this occurs in nature is not definitely known. The habits of this beetle are very similar to those of *Scolytus multistriatus*. It breeds in elm logs and dead or weakened elm trees. Young adults usually dig short tunnels into the bark on the trunks and branches of healthy elms before attacking elm logs and dead or weakened elm trees for breeding (Figure 6, lower left).

In central Massachusetts, this beetle has one complete generation and a partial second. Farther south it may have two. It is far more widely distributed than the introduced *Scolytus multistriatus*. It is present in all parts of Massachusetts and has been found throughout most of the range of the American elm.

The beetle is about the same size as *Scolytus multistriatus*, but differs from it in that it has a dull, uniform, dark brown color (Figure 5, B). Its egg gallery is dug more or less across the grain, and is two-branched, instead of being a single straight tunnel parallel to the grain (Figure 6, lower right).

Some Suspected Insect Vectors

Some other insects which bore in elm trees may prove to be carriers. At present, however, they are not known to be of any consequence.

One of these is the elm borer, *Saperda tridentata* Oliv. This is a beetle about one-half inch long, colored gray with red stripes. The larva is nearly an inch in length. It makes a long winding tunnel beneath the bark. The adult usually feeds on elm leaves before laying eggs in a shallow puncture in the bark.

Two closely related beetles known as the elm snout beetles, *Magdalis barbita* Say., and *Magdalis armicollis* Say., which have habits somewhat similar to *Saperda tridentata* Oliv., are also regarded with suspicion. The adults of of these two beetles are black and brown respectively and are about one-fourth of an inch long. The larvae or grubs resemble those of *Scolytus multistriatus*.

The buffalo tree hopper, *Ceresa bubalus* Fabr., and several other insects which attack elms are likewise suspected of being possible vectors.

CONTROL PRACTICES

At present, the introduction of diseased elm trees or burl-elm logs into the United States is prevented by federal quarantines. Within the United States, local quarantines have been established to limit further the transit of the Dutch elm disease beyond the boundaries of areas having infested trees.

Measures to control the Dutch elm disease in the regions of the United States where the disease is known to occur are directed toward preserving healthy trees by the careful, prompt, and thorough eradication of all elms known to be infected, and a supplementary sanitation program.[1] Whether or not elms are located in an area where they are exposed directly to the Dutch elm disease, it is a good practice to keep them in a healthy condition and free from dead branches in which beetles might breed. However, there is no complete assurance that an elm which is relatively healthy will not be affected by the disease, since experience has shown that the "average elm" is susceptible.

In Europe, no general eradication program has been carried out and attempts to control the disease by occasionally destroying affected trees in various places have failed to show any constructive results. In the United States, persons charged with the responsibility for the federal control program have expressed the encouraging opinion that eradication of the disease in this country is an attainable goal. But no program except a planned and sustained campaign against the disease can possibly achieve success in the eradication or even the practical control of the Dutch elm disease.

Reports on the introduction of zinc chloride and copper sulfate into the sap stream as a means of impregnating and poisoning against further attack by fungi and insects indicate that a means is at hand for destroying organisms in "doomed trees" whenever the actual removal of the trees must be delayed for any reason. However, only trees which are definitely scheduled for destruction should be treated by this process since *treated trees are certain to die.* Moreover, it must be borne in mind that as yet the practice of the distribution of poisons by the sap stream in elms cannot be transferred to industry in the place of pressure processes used on felled trees for the preservation of heavy service woods.

THE FUTURE OF ELMS IN MASSACHUSETTS

At the present time the Dutch elm disease is not known to occur in Massachusetts. However, the oldest known American infestation of the principal carrier insect of the disease, the smaller European elm bark beetle, was discovered in the vicinity of Boston in 1909. With this known carrier already well established in Massachusetts, the elms of the State would be in grave danger of destruction should the Dutch elm disease be introduced among them. It is, therefore, most important that prompt discovery be made of the first cases of the disease that may occur in Massachusetts in order that immediate steps may be taken to eliminate all sources of infection. Every one is urged to cooperate in the effort to protect and preserve the elm trees of the State for future generations.

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[1] In one area where diseased and beetle-infested trees were not destroyed until most of the beetles had emerged, the diseased trees found the following year were much more numerous than those found in a similar area where the affected trees were destroyed soon after their discovery and before the beetles had emerged to any appreciable extent.

An Elm Blossoming in the Spring.

The Dutch elm disease threatens destruction of the American elm. The only hope of saving Massachusetts elms lies in early discovery and prompt destruction of the first infected trees found in the State. Watch for dying branches; wilting and yellowing leaves on terminal twigs; premature leaf-fall; brown streaks or spots showing in outer wood rings and under the bark of sections cut from wilt-affected branches. If these signs appear, cut six-inch sections of half-inch diseased twigs; label with the location of the tree and your name and address; wrap securely; and send to —

THE SHADE TREE DISEASE LABORATORY,
MASSACHUSETTS STATE COLLEGE,
AMHERST, MASSACHUSETTS.

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